SHOCK ABSORPTION OF AUTOMOBILE TIRES

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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SHOCK ABSORPTION OF AUTOMOBILE TIRES

A THESIS

PRESENTED BY

NORTON L. MARVIN AND MAURICE M. JACKSON

TO THE

PRESIDENT AND FACULTY

OF

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BACHELOR OF SCIENCE

IN

MECHANICAL ENGINEERING

MAY 27, 1920

APPROVED:

Professor of Mechanical Engineering

Dean of Engineering Studies

Dean of Cultural Studies

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TABLE OF CONTENTS.

Table of Contents.

Table of Contents	Page- 1
List of Illustrations	4
Introduction	5
Scope	8
Theory	11
Apparatus	16
The Machine	20
Regulation of Loading	22
Regulation of Tractive Effort	22
Recording Device	23
Electrical Equipment	25
Standards	26
Angle Bars	27
Pulleys	28
Bumper Pulley	29
Method	30
Analysis of Curves	33
Logs	39

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Table of Contents.

Curves	42
Suggested Changes	51
Conclusions	55
Calculations	58
Blueprints	62

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List of Illustrations.

Front View of Machine	Page-17
Side View of Machine	18
Recording Device	19
Traction Spots	63
Reducing Pulley	64
Standards	65
Angle Bars	66
Details of Recording Device	67
Standard for Recording Device	69

INTRODUCTION.

INTRODUCTION.

The progress of the motor car in the past decade has resulted in the refinement of all of our old standards and customs in the way of production. This refinement has necessitated the scientific standardizing and testing of all the parts and appurtenances which enter into this production.

The purpose of the tire is to absorb as much of the shock due to road irregularities as possible. Springs do much of this very work, but it is a fact that a large pneumatic tire with poor springs will suffer less from road shock than the same car when it is equipped with iron tired wheels and high quality springs.

A vast amount of research and experimental work was necessary in the building and perfecting of the tire of today, not only as to mechanical construction but as to chemical composition, as well.

At present the manufacturers are fairly well versed in the best compounds and treatments of rubber as well as the best methods of construction. However, up to the present time, a machine has not been constructed which will measure relative shock absorption of tires with any degree of accuracy and consistency.

It was with the idea of making a machine that would give these results that Professor George F. Gebhardt, Professor of Mechanical Engineering, Armour Institute of Technology, designed and constructed the machine which enabled the writers to obtain the following data. The analysis of this data comprise the subject matter of this treatise. It is not in the scope of this thesis to give a complete and comprehensive report on the subject because it is too large to cover in the time allowed. It is the aim of the authors to make a preliminary survey of the subject so that future Senior students in the mechanical department will continue this work and obtain more detailed results which will necessarily lead into a clearer insight of the subject.

SCOPE.

SCOPE.

A theoretically elastic body will absorb all of the shock subjected to it. A theoretically inelastic body will absorb none of the shock subjected to it. The automobile tire lies in between these limits and the amount of shock absorbed is dependant on several variables. Among these variables are speed, static load on the tire, air contents of the tire, pressure within the tire, tractive effort of the tire, etc. For a given run all of the variables are held constant except the variable under observation which is varied from minimum to maximum points. Due to the heat generated by friction between the tire and the road or in our case the bumper pulley and also due to the work necessary to compress the section of the tire just in front of the section compressed, there is a power loss. This power loss also is dependant on the same variables.

The amount of area of the tire which flattens out on the plane surface of the road when the tire is at rest is a measure of the static forces which enter into the problem. This measure is purely relative.

Some of the variables which will affect this area are the static load on the tire, the air pressure in the tire and the construction of the tire.

The other items worthy of consideration are the speed of the tire, size of the tire (from the viewpoint of its moment of inertia) and the power lost due to slip, compression and heat generated.

The scope of this thesis is therefore to correlate all these factors and establish mathematical relationships between them, if possible.

THEORY.

THEORY

The theory underlying the shock absorption of tires is very complex because of the extremely large number of variables which enter into the problem. Before proceeding further into the theory of the subject, two important definitions are in order.

The flexibility of a body is relative to the amount of strain produced in a body by a given stress. The greater the strain for a given body the more flexible the body is said to be.

$E = \frac{S}{\delta}$

E = modulus of elasticity.
S = stress in pounds per sq. inch.
δ = elongation in inch of stretch per inch of length.

Hence, the modulus of elasticity of a body is a true measure of the flexibility of the body. The smaller the modulus the greater the flexibility.

$\phi = \frac{K}{E}$

ϕ = coefficient of flexibility.
K = constant.

The resilience of a body is relative to the coefficient of restitution of the body.

$$\rho = \frac{V}{U}$$

ρ = coefficient of restitution.
V = velocity after impact.
U = velocity before impact.

The higher the coefficient of restitution of a body, the higher the resilience is said to be. The coefficient is a figure which is obtained only by experimentation, and similar to the coefficient of friction, it is dependant on the two bodies in contact.

Let us assume that we have a body and we drop it on some fixed body. The first body starts out with a potential energy and has it changed to kinetic energy as it goes down. When the first body strikes the fixed body there will be a flexure in both the moving body and the fixed body, which flexure requires work. This work is lost and the more work which is used in flexing the bodies the less work available for raising the moving body. The more work lost, the less the resilience is said to be.

The resilience is usually mentioned with respect to the moving body, tho this is not essential. The

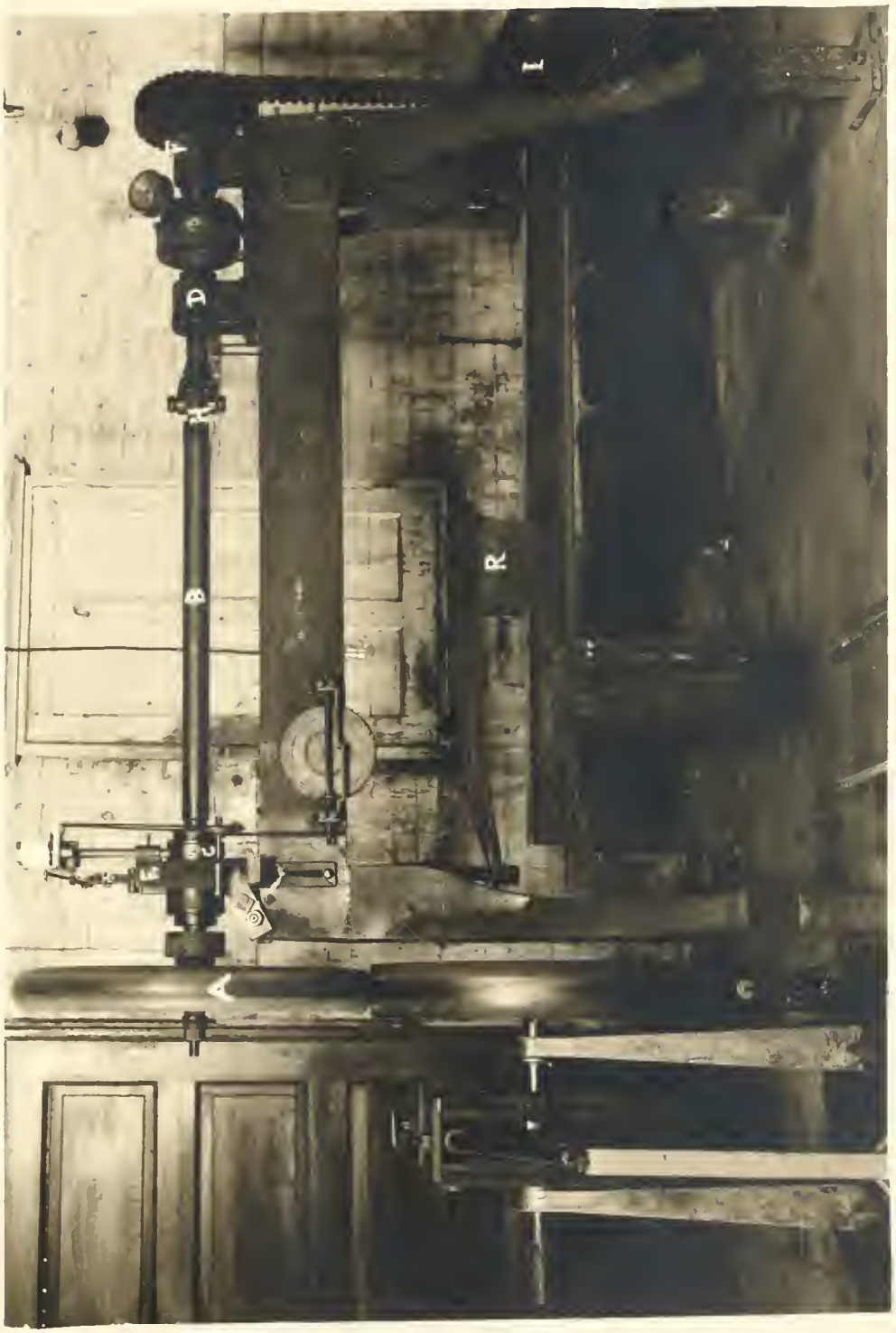
way two bodies could be tested relatively is by dropping both from the same height on the same fixed body and measuring the return distance. The one which returns higher is said to be more resilient.

With our testing machine a roll of paper is moved past a pencil which is actuated by a bumping tire. The tire revolves a bumper pulley on which is a single bump. The tire receives a shock and then is allowed to recuperate from its effect.

What happens is this. The tire receives a bump and a peak is recorded on the chart. Due to the flexibility of the tire and the bumper pulley, when the tire falls there is a valley recorded on the chart. Due to the resilience there is another peak registered when the tire rebounds, and so on until the bump comes around again. It is the writers' contention that the peaks show resilience and the dips show flexibility. For comfortable riding qualities the tire should not be so resilient that it keeps bouncing up and down or so flexible that the same effect is produced.

The way the shock absorption qualities are tested in this work is by varying the governing conditions and observing the relative change in the peaks and valleys of the curves.

APPARATUS.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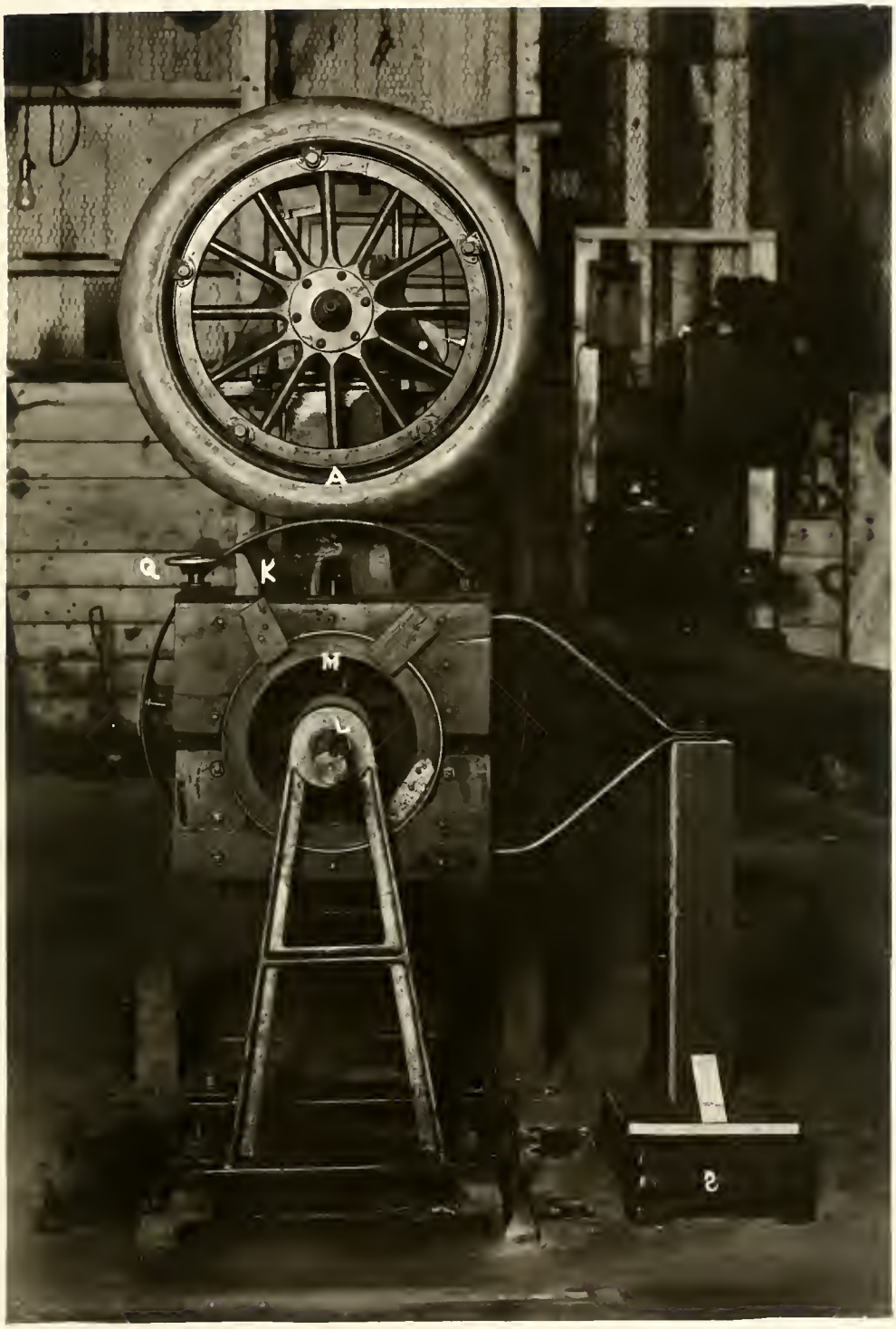
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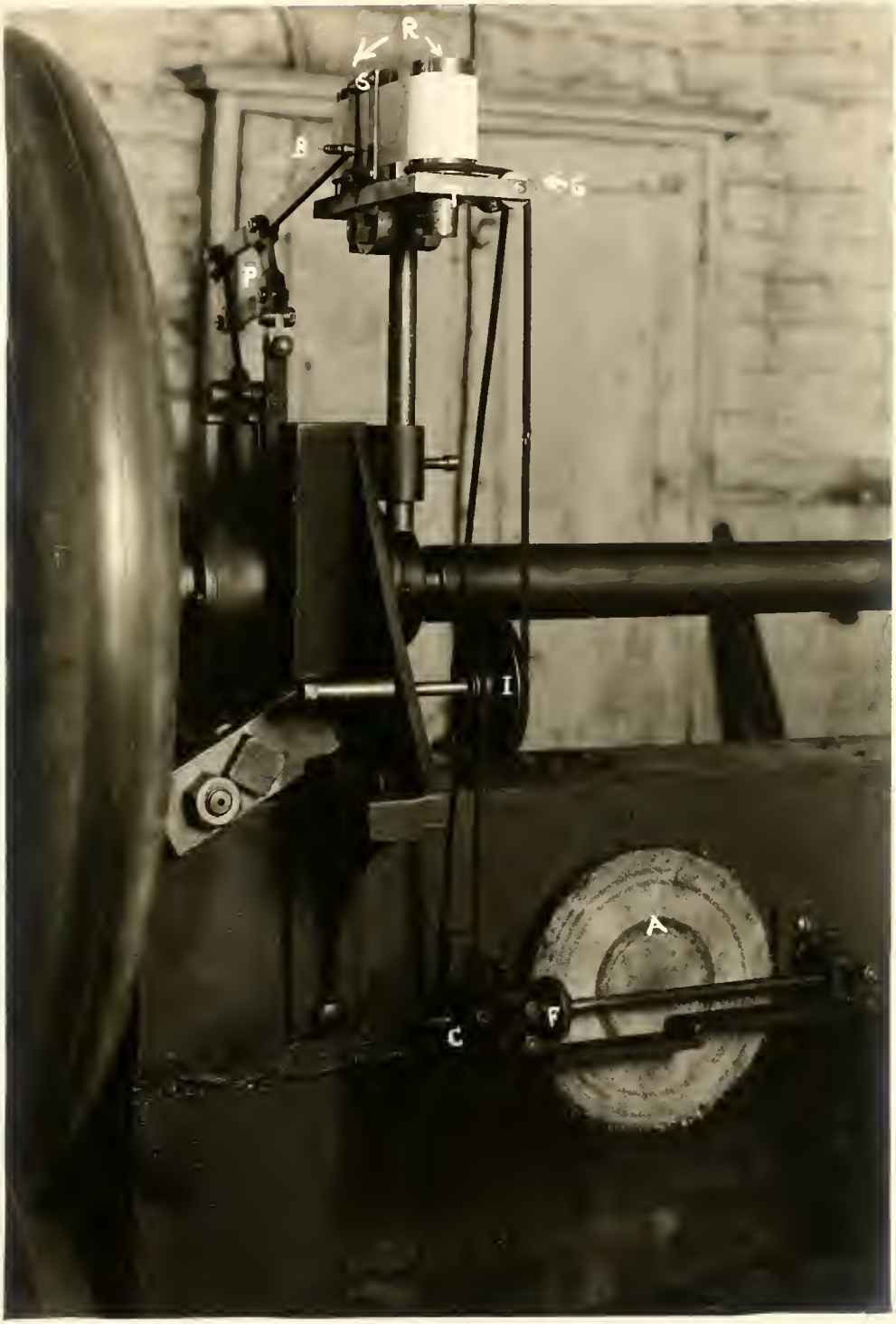
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APPARATUS

THE MACHINE

The machine as originally designed is shown in Figure 1. with the exception of the recording apparatus and extension pieces on the standards which were designed and constructed by the writers. In building this machine practical conditions were kept in mind so that when a tire was set up ready to run, it would be subjected to conditions similar to those met in actual running. The tire (a) is shown mounted on a standard wooden automobile wheel which is attached firmly to the shaft (b). This shaft rotates in three roller bearings (c) (d) and (f). The bearings (d) and (f) are rigidly connected to the frame by bolts while (c) is set in a block which is free to move up and down between ball bearings in the slotted guides (e). A universal joint is placed in the shaft at (h) to take care of the up and down motion due to the irregularities in the idler pulley on which the tire runs and also the irregularities in the tire itself. The main shaft is driven by a chain and sprocket wheel from a shaft (i) directly below it. This shaft is driven directly by belt

from a 15 Horse power variable speed motor.

REGULATION OF LOADING

A very ingenious method is used to vary the load on the tire and at the same time have it applied thru a spring. An I beam is swung from steel straps at the right. At (R) it is attached to the large end of a cantilever spring. The other end of the spring is attached to a rod which swings thru universal joints from the bearing block (c). By slipping weights on the beam the load on the tire can be adjusted to any predetermined amount.

REGULATION OF TRACTIVE EFFORT.

A Prony brake was used to measure the tractive effort and to calculate the horse power output. Figure 2. shows the tire (a) resting on the idler shaft of the Prony Brake. This shaft is mounted in roller bearings set in standards (i) as shown with the friction wheels (m) which is also keyed to this shaft between the standards and the idler overhanging the far end. The tractive effort is adjusted by turning

the small wheel (q) which tightens or loosens the straps of the brake increasing or decreasing the tractive effort which is measured by the scales (s).

The Horse power output is calculated from the wellkown formula $HP = \frac{2\ \pi\ Gan}{33000}$. The machine, motor and brake are securely bolted to the cement floor by means of expansion bolts which eliminates all vibration.

RECORDING DEVICE.

The recording device upon which so much depends in a test of this kind is shown in Figure 3. The original driving mechanism is used. This consists of a disc (a) which is driven thru proper gears, shafts and belts from the main shaft. A pantograph (p) is used to record the distances the tire raises and lowers. One corner of the parallelogram is attached to one of the guides and the opposite corner to the bearing block. A pencil is placed at (p) and as the tire moves up and down the pencil traces a record of the movement of the tire in a vertical plane. The original recording device con-

sisted of a disc rotated by means of a belt running over the pulley (c). The speed of the shaft to which (c) is attached can be adjusted by sliding the wheel (f) inward or outward on the disc (a). The speed of rotation is increased by moving it outward.

A piece of paper was pasted on the disc and as it rotated the irregularities in the idler and tire caused the pencil to move up and down and trace a curve about the center of the disc. This method was unsatisfactory because only very short runs could be made and a comparison of these curves was difficult. Thus, a recording device which would give continuous and consistant curves that could be compared with reasonable accuracy and precision was of utmost importance. In order to get continuous curves, it was necessary to use a roll of paper and to pass the paper at constant speed under the pencil attached to the pantograph. So the arrangement as shown was used. Two brass rollers (c) were set upon shafts mounted on the framework (f) a flat vertical strip (s) between the rollers allows the paper to pass freely under the pencil. Two brass plates are attached to this strip.

The paper is threaded under these and in this way is kept from moving up and down with the pencil. The paper is first wound on one of the pulleys and the end attached to the other pulley by a clip. This pulley is connected thru an idler to pulley (c). The other pulley is belted as shown over two idler pulleys (g) which change the direction of the motion of the belt.

For the purpose of increasing the motion of the recording paper rolls, it was found necessary to increase the speed ratio of the mechanism giving a greater length of paper per revolution of the tire. This pulley revolves on a shaft which is rigidly attached to the frame of the machine. The details of construction are shown on a blue print.

ELECTRICAL EQUIPMENT

The apparatus is run by a variable speed direct current motor. The voltage necessary is 115 volts. The maximum current is 116 amperes and the maximum power is 15 Horse-power. The speed is

controlled by a controller similar to those used on street railways. The speed is controlled by varying the resistance. An ammeter was put in service in the line and a voltmeter shunted across the line. The motor was protected by two 75 ampere fuses.

STANDARDS

The standards for raising the entire machine are shown on a blue print. The purpose of these standards is to make the old machine capable of testing larger size tires. It is possible with the addition of these standards to test a 46 inch wheel. All the machining necessary on these castings was the drilling of a 41/64" hole in the top and four (4) 41/64" holes in the flange on the base. The old holes in the base of the machine were not in the center, hence 5/8" holes were drilled in the old casting. These holes were then tapped with a standard 5/8" holt tap. A bolt was used to fasten the new castings to the old machine. The bolts were made long

enough to put a nut on and peen the end of the bolt so that the bolt would not become loosened by vibration.

ANGLE BARS.

It was found necessary to raise the bumper shaft bearing standard $2\frac{1}{2}$" and also move the whole brake shaft closer to the machine 1 5/8". The brake shaft was raised so that the tire which rests on the bumper pulley would be raised. The tire had to be raised enough so that the tire shaft would be practically horizontal. If the shaft were not horizontal, we would have four critical speeds due to the single universal joint. The whole shaft was moved toward the machine so that there would not be an excessive bending moment on the brake shaft in addition to the twisting moment.

The raising of the shaft could have been accomplished by blocks and shims. However, in view of the fact that the whole brake shaft had to be moved 1 5/8", it was decided to use angle bars as shown in blue print. The bottoms of these bars were machined

to insure a flat plane surface and the holes were drilled as shown.

PULLEYS

The speed with which the tire runs is one of the very important considerations of the thesis. It is necessary to have speeds which are concordant with practical use of the tire. The motor has a rotational speed of from 500 r.p. m. to 1800 r.p.m. There are two reductions from the motor to the driving shaft. One of these is fixed at 2 to 1 and the other is calculated to suit conditions. The pulleys finally decided on were a 5 inch pulley for the motor and a 12 inch pulley for the machine. Inasmuch as the shaft of the motor is $2\frac{1}{4}$" and the hole in the pulley 2 5/8", it was necessary to machine a bushing of the correct size and mill a slot in the bushing 5/8" wide for a key way. A slot for the key in the shaft is 1/2" and the slot in the bushing and the pulley are 5/8" . The key was made 5/8" wide for 1/2" the thickness and 1/2" for the other half.

The bushing was machined from a solid shaft of mild steel. The pulley is $4\frac{1}{2}$" wide.

The machine pulley which is 12" in diameter is 4" wide. As the hole is a trifle over 2" and the shaft is just 2", it was only necessary to use a piece of thin metal for the bushing. The key had to be made similar to the last, viz 5/8" wide for the pulley and 1/2" wide for the shaft.

BUMPER PULLEY.

The bumper pulley is 27 inches in diameter and 4 inches wide. The hole in the pulley is $2\frac{1}{4}$" while the shaft is $1\ \frac{31}{32}$" diamater. A bushing was cut from a solid mild steel shaft and a slot was milled in 5/8" wide. The bump was cut from a piece of maple and was made 1/4" high, 5" long and 4" wide. It was curved to fit the pulley and then bolted to the pulley with two (2) 1/4" stove bolts.

METHOD.

METHOD.

In general the method of procedure is to get a set of conditions on the machine, then start the chart in motion and obtain a set of curves for that one set of conditions.

For instance, in our first run we had a certain static load on the tire. We started the motor and ran at its slowest speed. The load on the brake shaft was then set for a given tractive effort and the chart was set in motion. This constituted one run. Our second run was the same only the speed was increased and the load on the brake shaft set so that the tractive effort was the same as in the first run made. Again the chart was set in motion for a characteristic set of curves for this condition. The speed was again increased and the load reset for the same tractive effort and another run made. The speed was increased until the vibrations became too intense to get consistent curves. The next set of runs was the same except that the pressure was increased. Series of runs were made at various pressures and then

another series made with a greater static load on the tire. Another series of runs was made with an increased tractive effort.

After all runs were completed, traction spots were made for all runs possible. This traction spot was formed by allowing the tire to come down on a flat board. The board was marked with chalk and the tire was dampened with water. The amount of tire in contact with the plane surface was then seen by the part of the board from which the chalk was removed. Onion skin graph paper was laid on this spot and the outline of the spot traced.

The amount of travel of the paper of the chart to one revolution of the tire was determined by measuring the distance between the peaks which represent the bump on the wheel on any run.

The ratio of the amount of distance traveled by the pencil of the pantograph to the distance traveled by the shaft of the tire was determined by moving the shaft of the tire up with a block and pinch bar and measuring the corresponding distance traveled by the pencil.

ANALYSIS OF CURVES.

Analysis of Curves.

The curve of Run # 1 shows a very clear dissipation of energy within the tire.The neutral point is evidently between .80,which is the height of the last peak and .75,which is the height of the last dip. From the characteristics of the curve we will assume about .70. Due to eccentricities in the tire and bumper pulley the last two dips and peaks are not to be relied upon.

Run # 2 has the same conditions as the previous run except that the speed is increased. The curve produced is rather a good one and shows that with increased speed there is less time for the tire to recuperate from the shock.

Run # 3. The energy dissipated into the tire in this run will be difficult to find as there appears a little hump after the first peak which is manifestly due to some external force. What most likely occurred was that the

inertia forces of the static load or the eccentricity in the tire or bumper pulley was the cause of this.

Run # 4. A similar condition exists in this run also.

Run # 5. The tire is travelling too fast and the bump consequently comes around too frequently.

Run # 6. The speed was too excessive for any attempts to make an analysis.

Run # 7. The next set of curves cover the same speed with the same load and tractive effort but with increased pressure in the tire. The general aspect of these curves shows less shock absorption than with lower pressure. The curve is really an ideal one.

Run # 8. Not much of any value can be gleaned from this curve as there are a series of fluctuations which are irregular and occur just before the bump.

Runs # 9 & 10. These also are absolutely useless from our point of view.

Run # 11. A curve was produced which shows that with the increased speed less shock is absorbed.

Run # 12. A fine curve was produced and with it the shock absorption qualities may be compared for changes in tractive effort.

Run # 13,14 &15. These curves are valueless because they record peaks and valleys which must result from forces which are not known to the writers.

Run # 16. This graph corroborates the former contention that increased decreased shock absorption.

Run # 17 and 18. these curves which were conducted under a lower pressure point to the fact that a better shock absorption is taking place under the new conditions.

The curves of Runs No. 19 and 20 are valueless.

Run No. 21. This curve still further substantiates the previous contentions.

Runs No. 23, 24, and 25 are valueless.

In Run 26, the same thing happened as in Run No. 21.

Run No. 27. Wonderful absorption qualities occurred in this run when a very low pressure was in the tire.

Run No.29. A peculiar phenomenum took place during this run. The I beam which held the weights used for loading the tire set up a period of vibration. For about five or six revolutions of the tire the I beam would swing through a comparitively large arc; then for another five or six revolutions it would remain comparitively still and then the cycle would be repeated .

Run No. 30. This run which is with high pressure and higher static load shows better shock absorption than the same pressure and a lower static load.

Run No. 31. Very good curves were recorded in this set of conditions.

Run No. 34. This set of curves show that for high speeds the tire has not time to recover from one shock before being subjected to another one.

No other curves were of value.

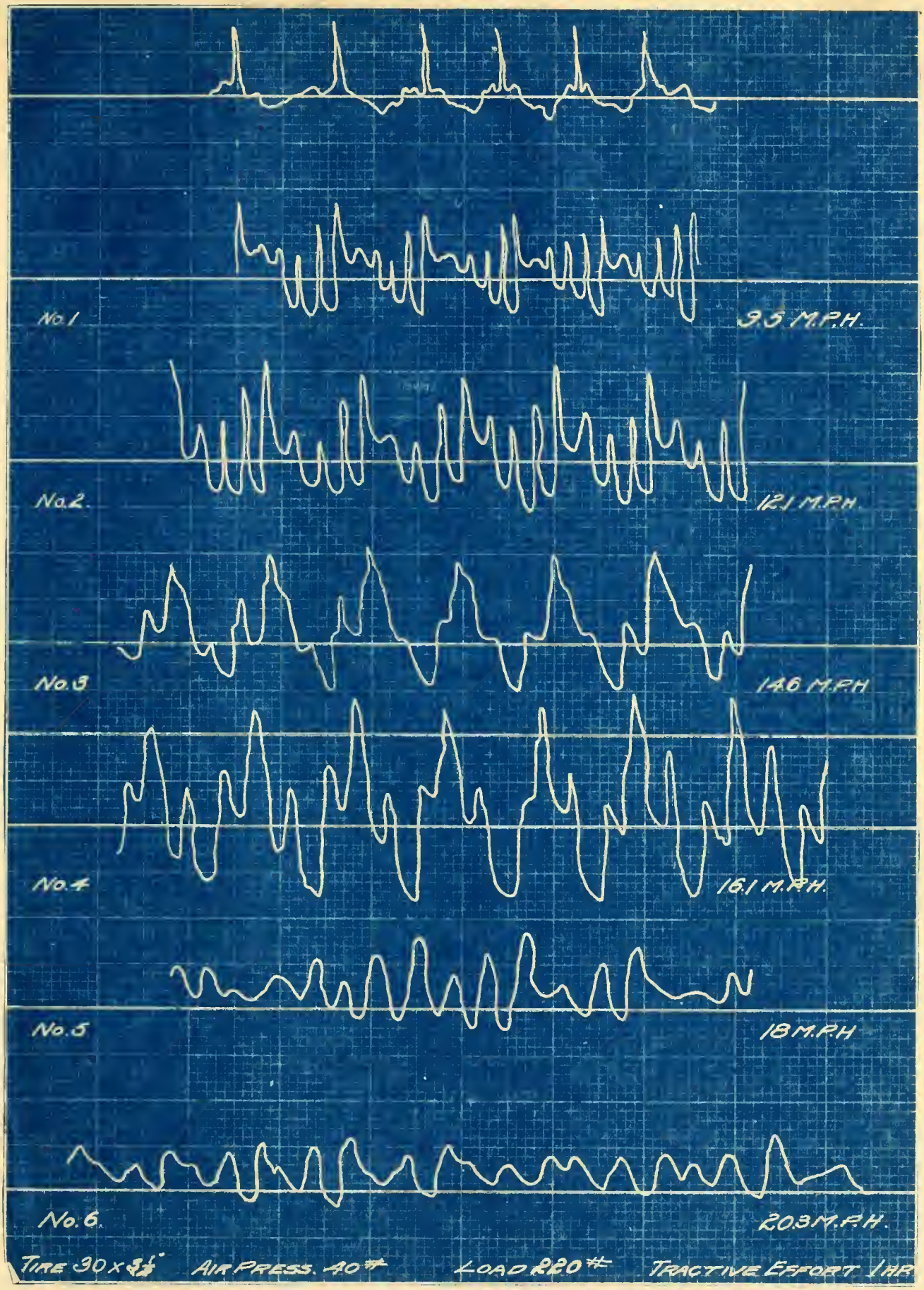
The authors originally intended to find the energy dissipated in the tire after each bounce, but, because the neutral line could not be definitely established, this idea was abandoned. If the eccentricity in the tire and the bumper pulley could be elliminated, the neutral line could be definitely established and a great stride would be taken along the perfection of the machine.

LOGS.

Run	Brake Shaft		TIRE				Elec. H.P. Input			Area of Traction Spot
	R.P.M.	Gross Load	M/H	Tract. Eff.	Press	Load	Volts	Amps	H.P.	
1	118	28.0	9.5	1 H.P.	40#	420	113	18.5	2.8	6.00 sq. in.
2	150	25.3	12.1	1 H.P.	40#	420	112	19.3	2.7	6.00 " "
3	182	22.1	14.6	1 H.P.	40#	420	112	19.3	2.7	6.00 " "
4	200	20.7	16.1	1 H.P.	40#	420	112	20.0	3.0	6.00 " "
5	225	18.9	18.1	1 H.P.	40#	420	111	20.0	2.9	6.00 " "
6	251	17.6	20.3	1 H.P.	40#	420	110	22.0	3.2	6.00 " "
7	120	28.0	9.5	1 H.P.	65#	420	107	22.8	3.27	3.80 " "
8	150	25.3	12.1	1 H.P.	65#	420	110	20.0	2.95	3.80 " "
9	183	22.1	14.6	1 H.P.	65#	420	111	19.4	2.88	3.80 " "
10	200	20.7	16.1	1 H.P.	65#	420	110	20.0	3.2	3.80 " "
11	225	18.9	18.1	1 H.P.	65#	420	110	21.5	3.17	3.80 " "
12	121	56.0	9.5	2 H.P.	65#	420	110	28.0	4.1	3.80 " "
13	151	50.6	12.1	2 H.P.	65#	420	108	31.8	4.61	3.80 " "
14	182	44.2	14.6	2 H.P.	65#	420	108	31.5	4.56	3.80 " "
15	203	41.4	16.1	2 H.P.	65#	420	108	34.5	5.00	3.80 " "
16	225	37.8	18.1	2 H.P.	65#	420	108	36.5	5.27	3.80 " "
17	120	56.0	9.5	2 H.P.	55#	420	110	31.0	4.58	4.45 " "
18	150	50.6	12.1	2 H.P.	55#	420	110	34.5	5.07	4.45 " "
19	180	44.2	14.6	2 H.P.	55#	420	109	35.0	5.12	4.45 " "
20	200	41.4	16.1	2 H.P.	55#	420	110	35.0	5.17	4.45 " "
21	228	37.8	18.1	2 H.P.	55#	420	110	39.0	5.75	4.45 " "

Run	Brake Shaft		TIRE				Elec. H.P. Input			Area of Traction Spot
	R.P.M	Gross Load	M/H	Tract. Eff.	Press	Load	Volts	Amp.	H.P.	
22	120	56.0	9.5	2 H.P.	45#	420	110	33.0	4.87	4.95 sq. in.
23	151	50.6	12.1	2 H.P.	45#	420	110	33.5	4.95	4.95 " "
24	180	44.2	14.6	2 H.P.	45#	420	110	32.5	4.80	4.95 " "
25	202	41.4	16.1	2 H.P.	45#	420	110	35.0	5.15	4.95 " "
26	222	37.8	18.1	2 H.P.	45#	420	110	35.0	5.15	4.95 " "
27	120	56.0	9.5	2 H.P.	35#	420	110	31.0	4.65	7.10 " "
28	153	50.6	12.1	2 H.P.	35#	420	110	33.5	4.92	7.10 " "
29	180	44.2	14.6	2 H.P.	35#	420	110	34.5	5.09	7.10 " "
30	120	56.0	9.5	2 H.P.	65#	470	110	33.0	4.87	
31	150	50.6	12.1	2 H.P.	65#	470	110	37.0	4.85	
32	180	44.2	14.6	2 H.P.	65#	470	109	35.0	5.14	
33	202	41.4	16.1	2 H.P.	65#	470	109	36.5	5.37	
34	225	37.8	18.1	2 H.P.	65#	470	109	39.0	5.70	
35	122	56.0	9.5	2 H.P.	55#	470	110	33.0	4.87	
36	150	50.6	12.1	2 H.P.	55#	470	110	34.0	5.02	
37	183	44.2	14.6	2 H.P.	55#	470	110	35.0	5.60	
38	202	41.4	16.1	2 H.P.	55#	470	110	39.0	5.75	
39	225	38.8	18.1	2 H.P.	55#	470	109	41.0	5.03	

CURVES.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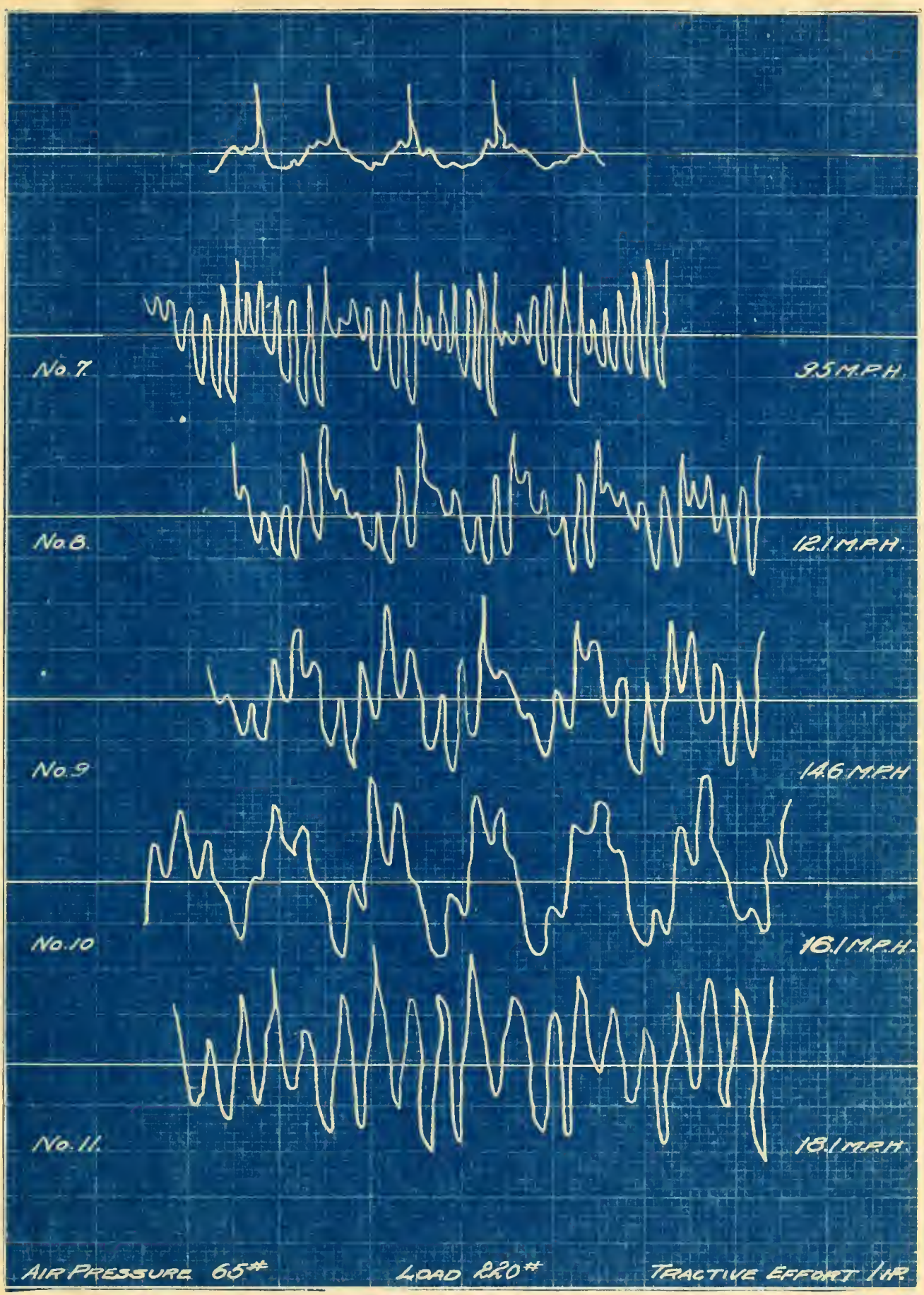
9.5 M.P.H.
No. 2.
12.1 M.P.H.
No. 3
14.6 M.P.H
No. 4
16.1 M.P.H.
No. 5
18 M.P.H
No. 6.
20.3 M.P.H.
TIRE 30 x 3½ AIR PRESS. 40 # LOAD 820 # TRACTIVE EFFORT 1 HR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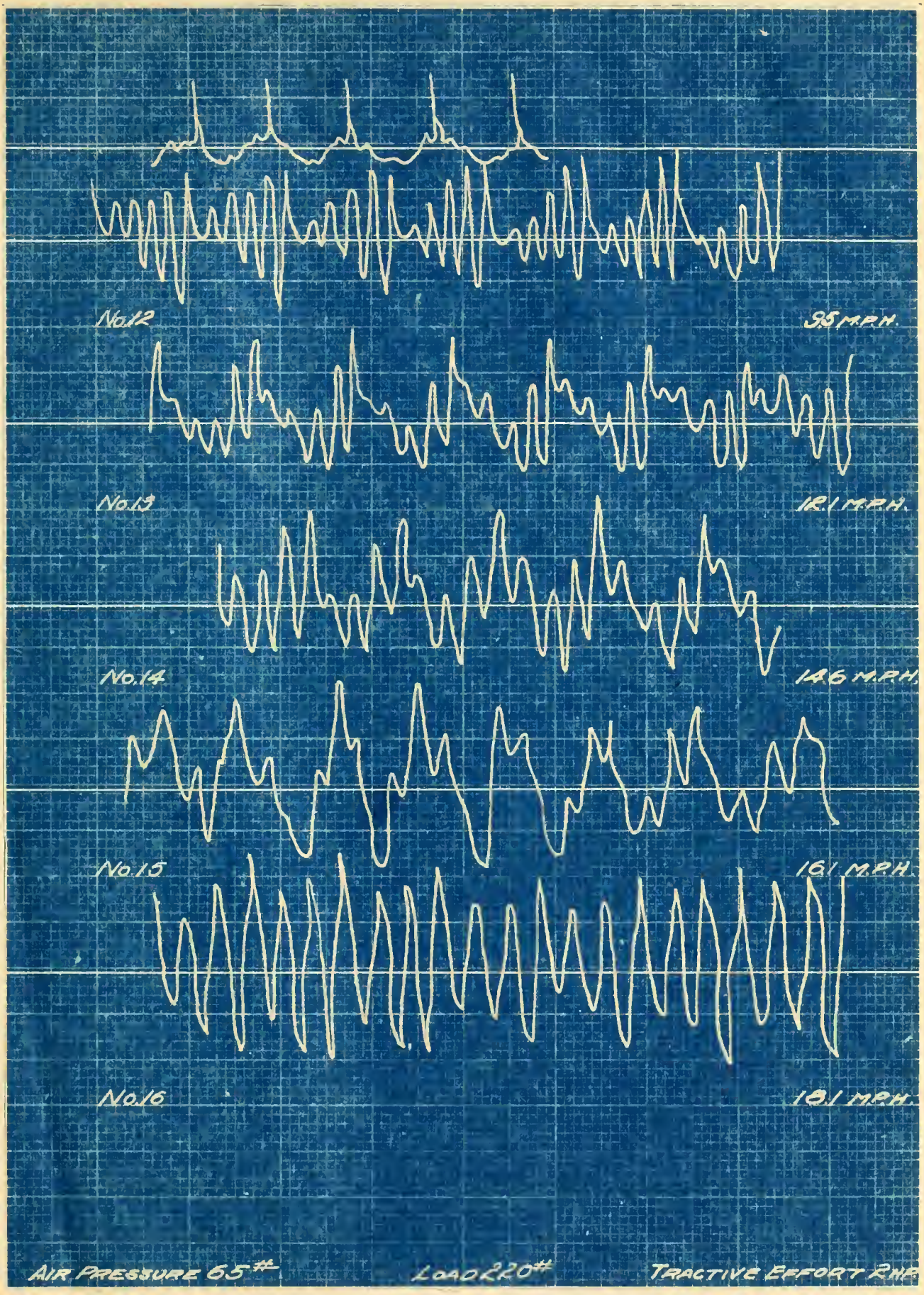
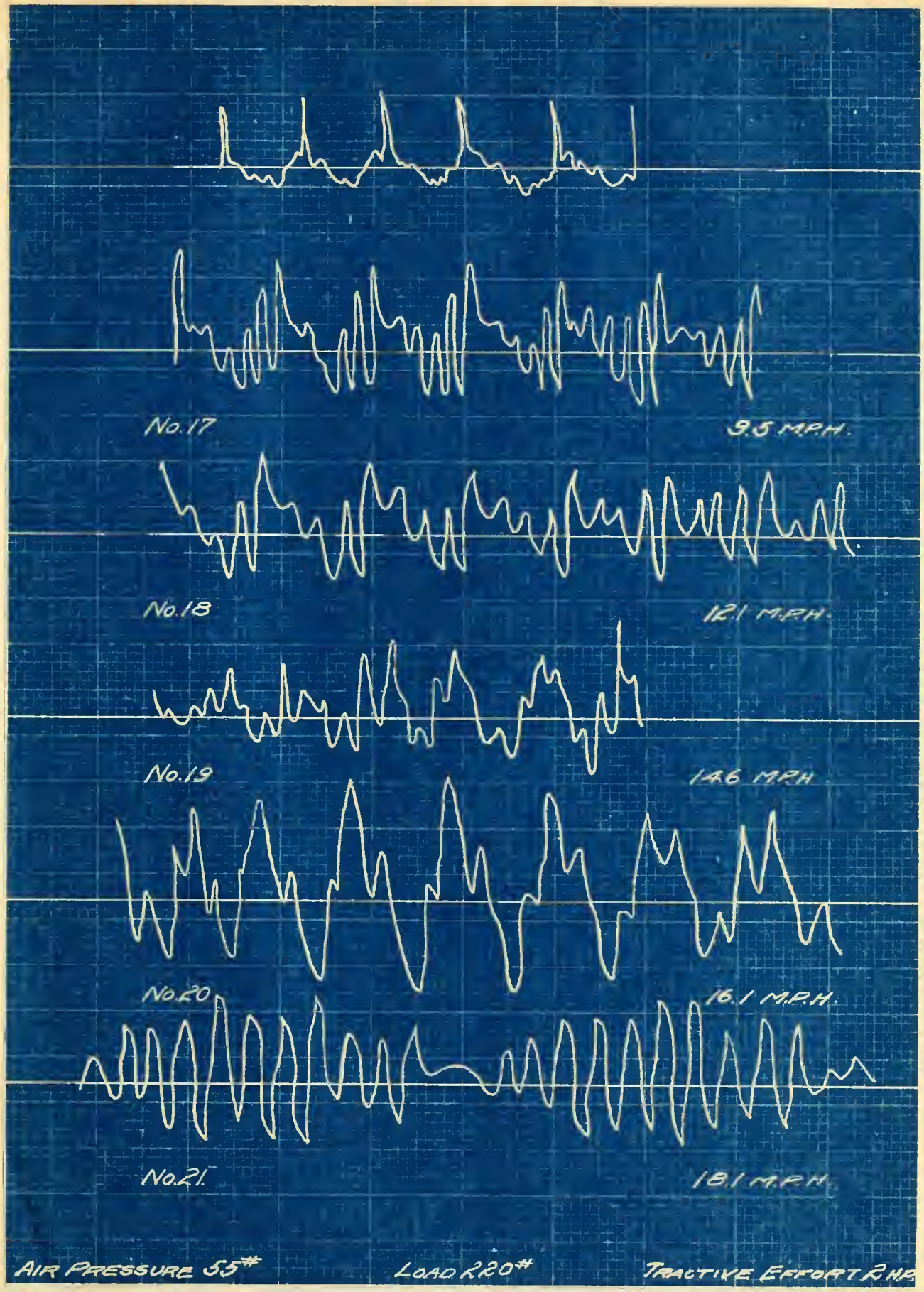
No. 9
14.6 M.P.H
No. 10
16.1 M.P.H.
No. 11.
18.1 M.P.H.
AIR PRESSURE 65#
LOAD 220#
TRACTIVE EFFORT 1HP.


No.12
9.5 M.P.H.
No.13
12.1 M.P.H.
No.14
14.6 M.P.H.
No.15
16.1 M.P.H.
No.16
18.1 M.P.H.
AIR PRESSURE 65#
LOAD 220#
TRACTIVE EFFORT 2HP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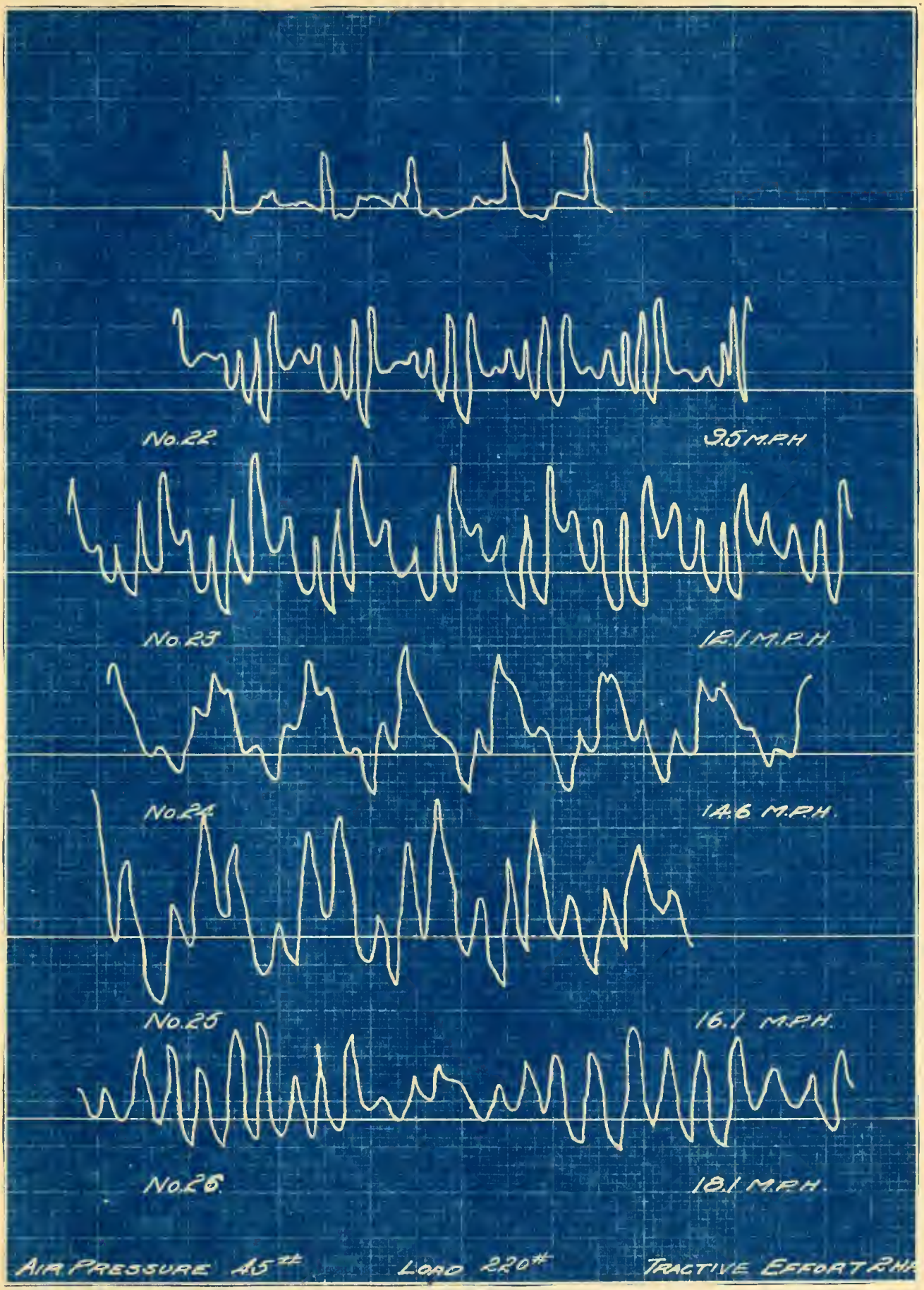
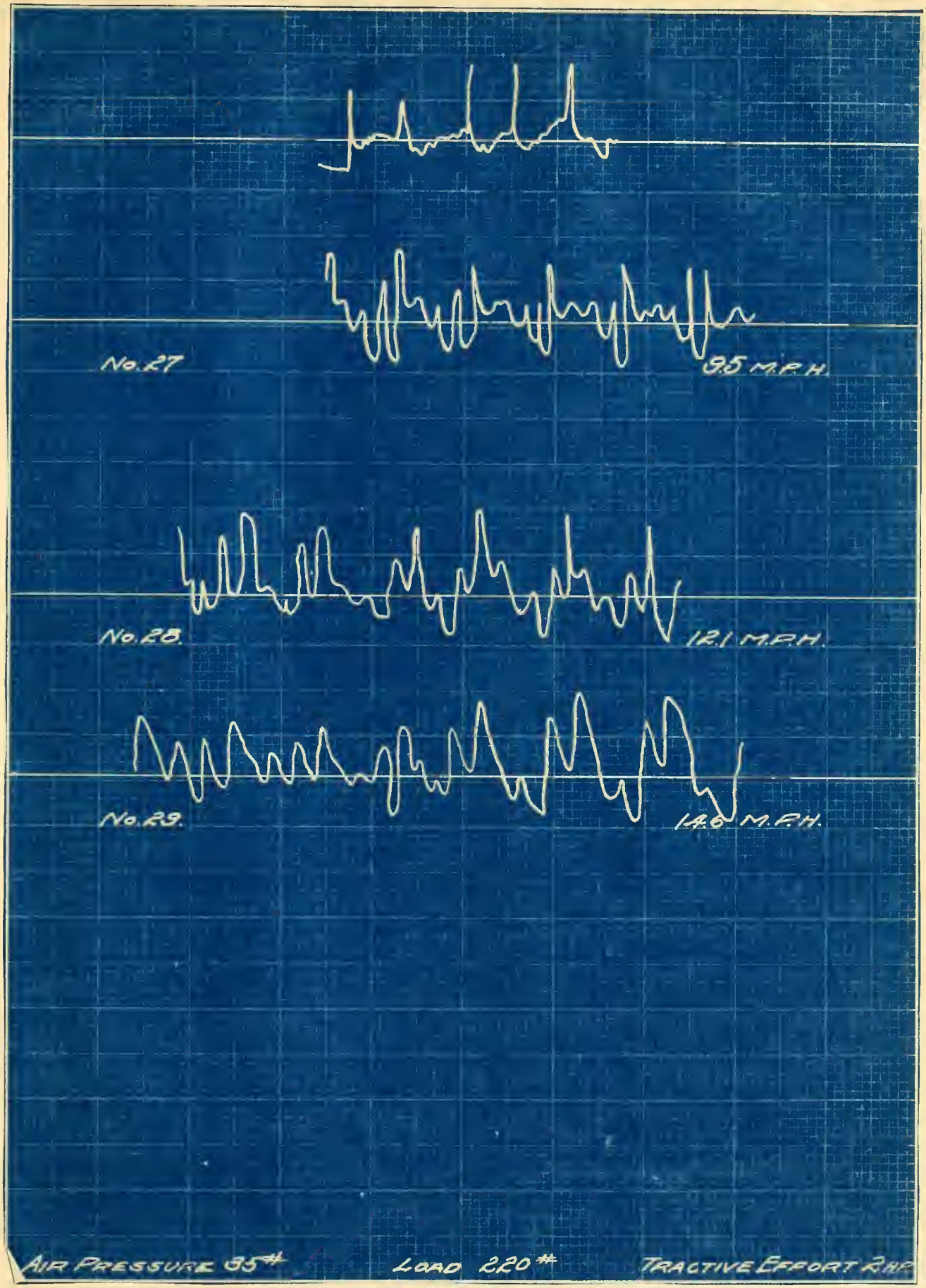
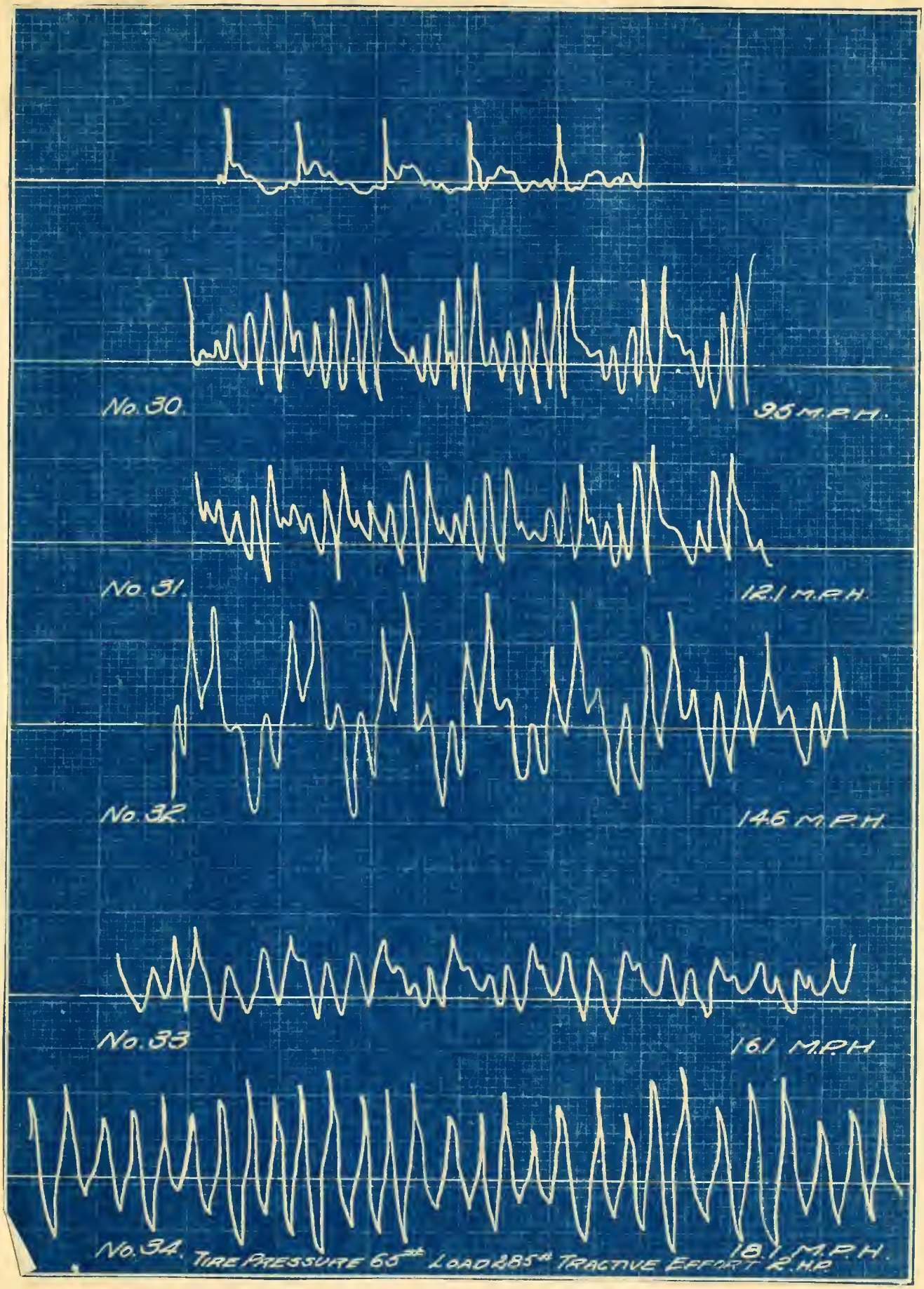
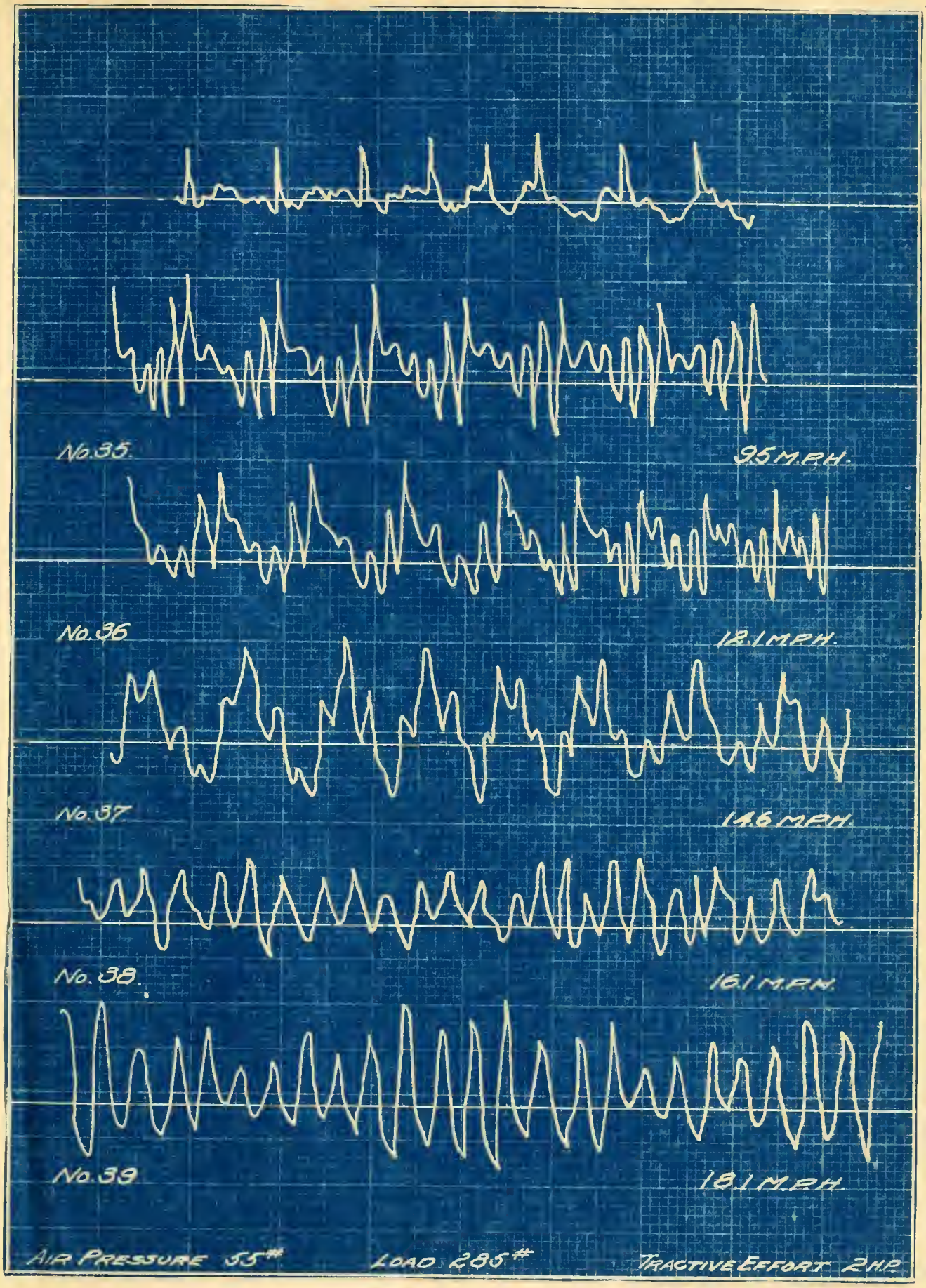
No. 18
12.1 M.P.H.
No. 19
14.6 M.P.H.
No. 20
16.1 M.P.H.
No. 21.
18.1 M.P.H.
AIR PRESSURE 55#
LOAD 220#
TRACTIVE EFFORT 2 HP.


No.22.
9.5 M.P.H
No.23
12.1 M.P.H.
No.24
14.6 M.P.H.
No.25
16.1 M.P.H.
No.26.
18.1 M.P.H.
AIR PRESSURE 45#
LOAD 220#
TRACTIVE EFFORT 2HP


No. 27
9.5 M.P.H.
No. 28.
12.1 M.P.H.
No. 29.
14.6 M.P.H.
AIR PRESSURE 35#
LOAD 220#
TRACTIVE EFFORT 2 HP


No. 30.
9.5 M.P.H.
No. 31.
12.1 M.P.H.
No. 32.
14.6 M.P.H.
No. 33
16.1 M.P.H
No. 34. Tire Pressure 65# Load 285# Tractive Effort 2. H.P
18.1 M.P.H.


No.35.
9.5 M.P.H.
No.36
12.1 M.P.H.
No.37
14.6 M.P.H.
No.38.
16.1 M.P.H.
No.39
18.1 M.P.H.
AIR PRESSURE 55#
LOAD 285#
TRACTIVE EFFORT 2 H.P.

SUGGESTED CHANGES.

Suggested Changes.

The bumps passed under the tire very rapidly at high speeds in this test. This proved to be a very objectionable condition, as the tire was not given time to recuperate from one shock before it received another. In order to eliminate this, it is suggested that an endless belt be passed over the present bumper pulley from a pulley about ten feet away. A very small sharp bump should then be fixed to this belt; with this change it will be possible to run at very high speeds, and to study more carefully, the effect of excessive speeds on the dissipation of energy in the tire. The bump should be about one half inch in height, and about one inch in length.

A great deal of trouble was experienced in getting the recording apparatus to function correctly.

It was impossible to obtain a speed

great enough for correct analyzation of the curves with the old driving mechanism, and, it was necessary to introduce an idler pulley to increase the speed.

With the use of this, the driving mechanism was overtaxed and a certain amount of slippage was always present.

We find that the speed of the rollers need not vary with the speed of the machine because, all that we are interested in, is the up and down motion.

In order to remedy these conditions, we suggest that a small constant speed moter be directly connected to the recording apparatus; this would do away with a great deal of complicated and worthless mechanism; the speed would be constant at all times, and the curves obtained would be very easily analyzed.

It is possible that the elimination of the spring would give a more comprehensive insight to this subject.

It was noticed that the vibration of this spring caused by the rapid succession of shocks instituted a harmonic motion which interfered with the correct interpretation of result.

CONCLUSIONS.

Conclusion.

In this treatise, no attempts were made for numerical results.

The factors influencing the shock absorption of tires were compared qualitatively rather than quantitatively.

We found that the traction spot increased, as the load increased, and the tire pressure decreased.

The amount of shock absorbed by a tire, seems to be affected by this traction spot as it was seen in our test that more energy was dissipated in the tire at lower pressure and heavier loads.

We also noted that the higher the speed, the less shock is absorbed within the tire.

It was observed that as the tractive effort increased, so did shock absorption increase.

The greater the static load on the tire,

the better the shock is absorbed by the tire.

Though the writers were unable to obtain numerical data, it is sincerely hoped that with the suggested changes as indicated heretofore, it will be possible for the men who take up the work next year, to obtain numerical results.

CALCULATIONS.

Calculation of
Motion of Tire to Pantograph Motion.

Test	Tire	Pantograph	Ratio
1	.44"	1.10"	2.500
2	.43"	1.21"	2.815
3	.56"	1.11"	1.984
Total	1.43"	3.42"	7.299
Aver.	.476"	1.14"	2.433

Therefore the ratio can be called 2½ to 1.

The energy at any point on the curve is equal to the height at that point multiplied by the total load mutiplied by the reduction ratio.

$$E = \frac{h \times W}{2.5}$$

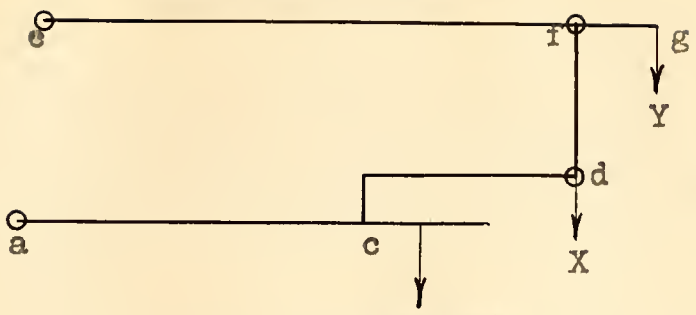
When the total load is 440 pounds

$$E = 176\ h.$$

When the total load is 485 pounds

$$E = 194\ h.$$

Load Calculations.



ef = 41.38"
eg = 51.13"
ac = 33.13"
ab = 43.75"
cd = 26.37"

$$ab \times L = ad \times X$$

$$43.75 \times 368.5 = 59.5 \times X$$

$$X = \frac{43.75 \times 368.5}{59.5} = 271\#$$

$$ef \times X = eg \times Y$$

$$41.38 \times 271 = 51.13 \times Y$$

$$Y = \frac{41.38 \times 271}{51.13} = 220\#$$

Total Load = Dead Load + Applied Load
= 200 + 220 = 420#

$$ab \times L' = ad \times X'$$

$$44.75 \times 470 = 59.5 \times X'$$

$$X' = \frac{44.75 \times 470}{59.5} = 353\#$$

$$ef \times X' = eg \times Y'$$

$$41.38 \times 353 = 51.13 \times Y'$$

$$Y' = \frac{41.38 \times 353}{51.13} = 285\#$$

Total Load = Dead Load + Applied Load
= 200 + 285 = 485#

Calculations.

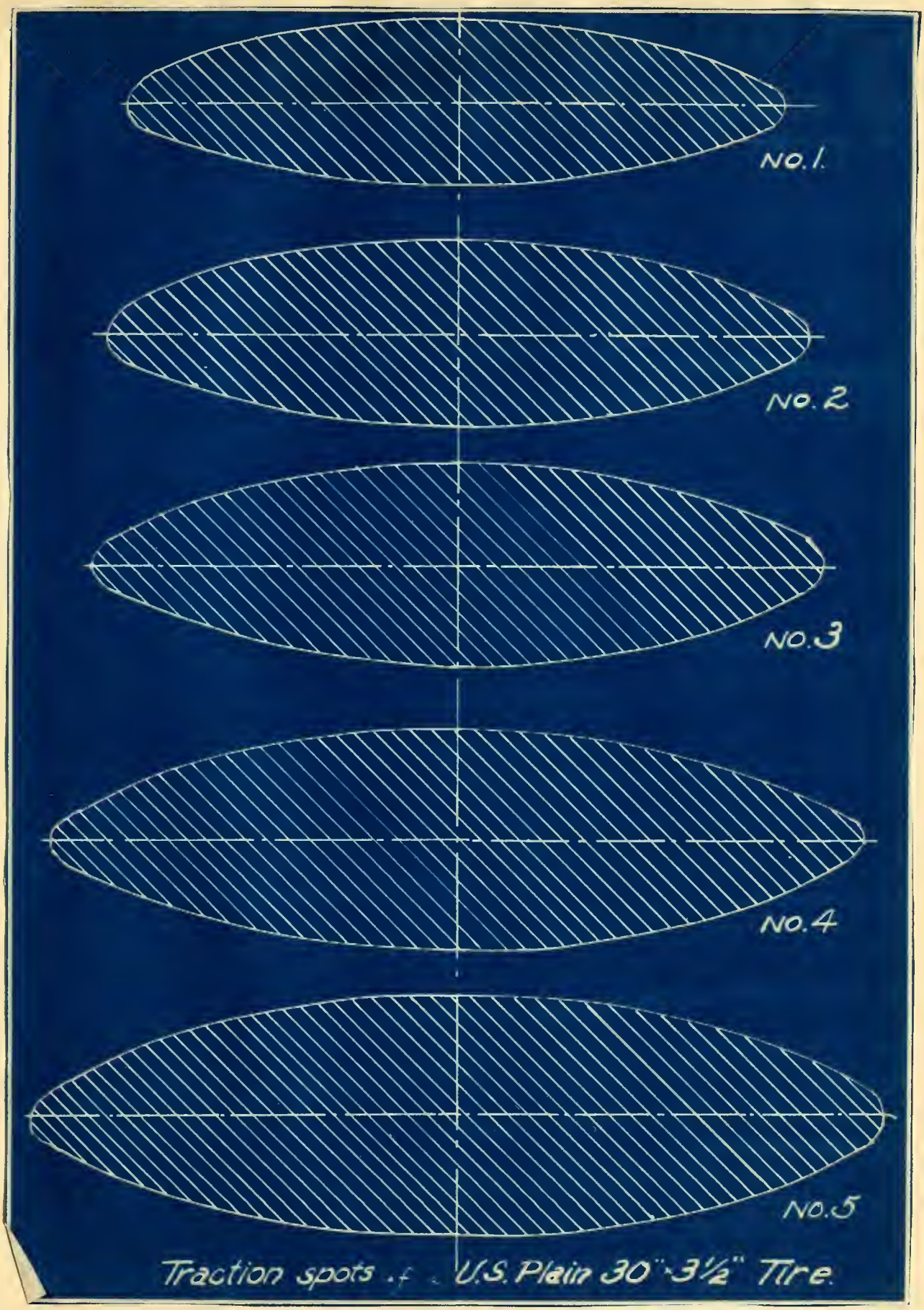
Determination of speed reduction between the motor and the machine to simulate average road speeds.

Speed range of motor, r.p.m...500...1800.
Fixed speed reduction..... 1:2..
Speed of tire assuming 1:1
ratio between motor and
machine.....250 ..900.
Size of tire, inches..... 30.
Circumference of tire, inches....94.25.
Speed of tire, miles per hour..22.3..80.3.

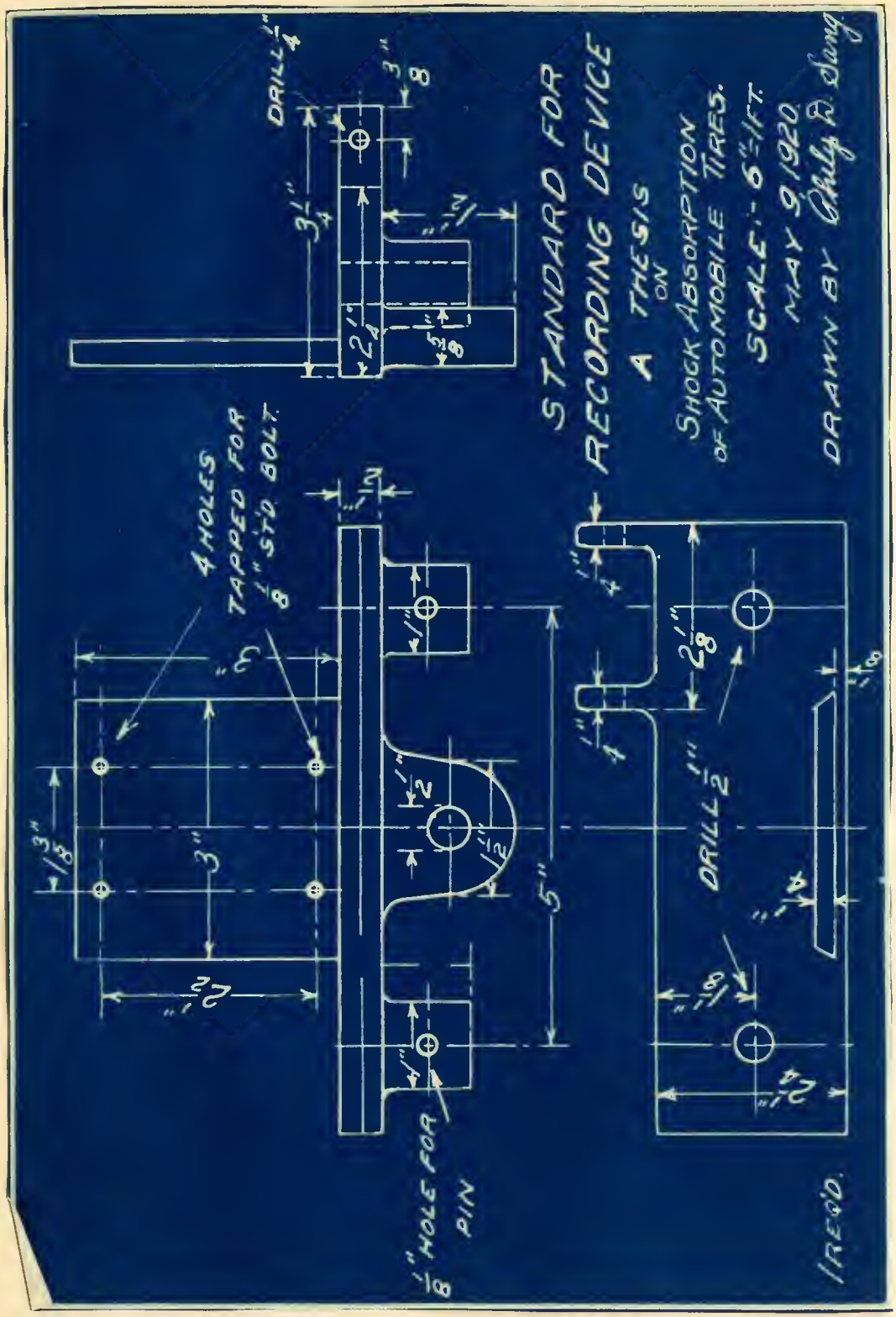
This speed is too fast and two pulleys are used for the motor and the machine which are 5" and 12", respectively. This is a speed reduction of 1 : 2.40.

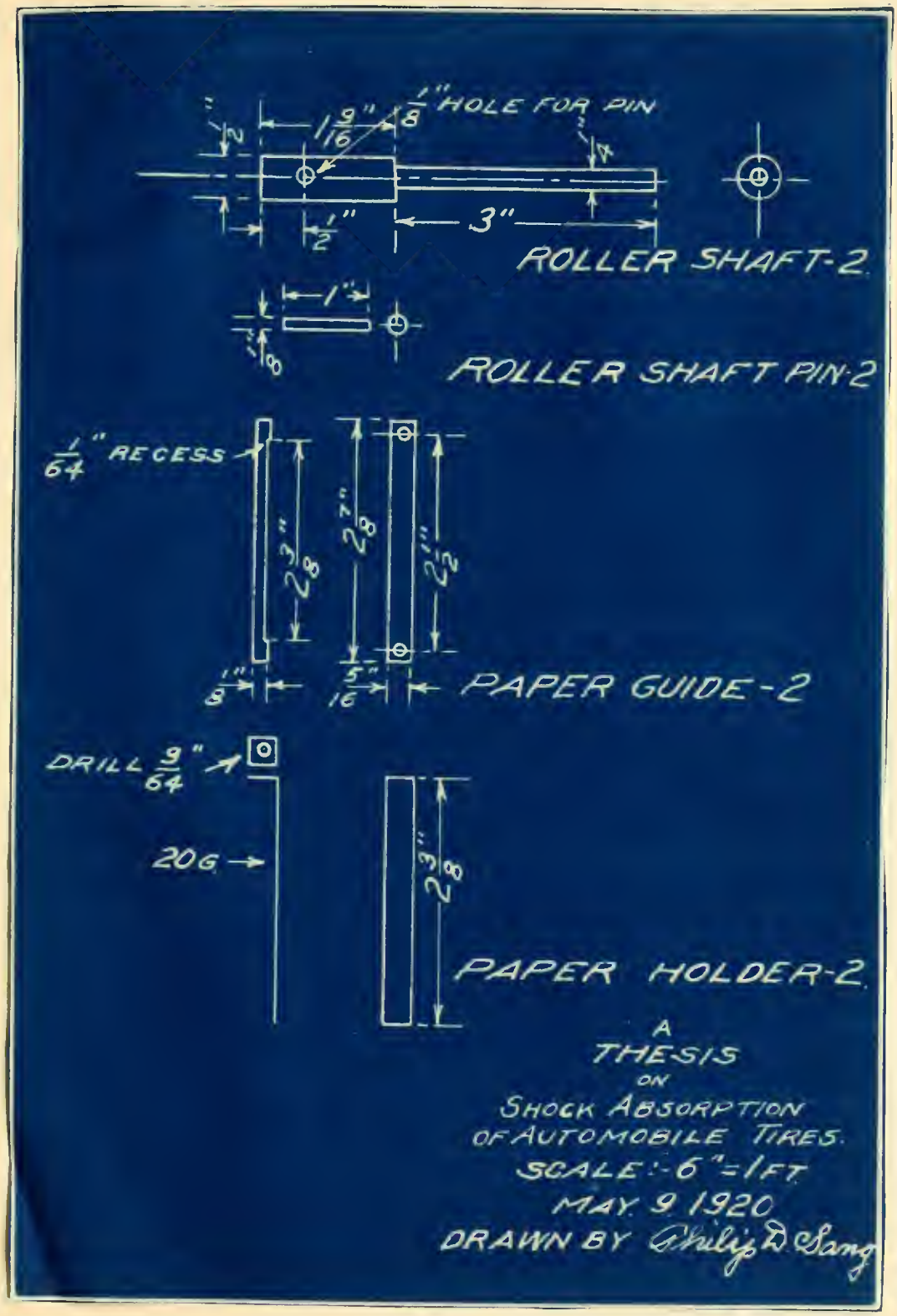
Actual speed of tire ....9.3....33.5 m/hr

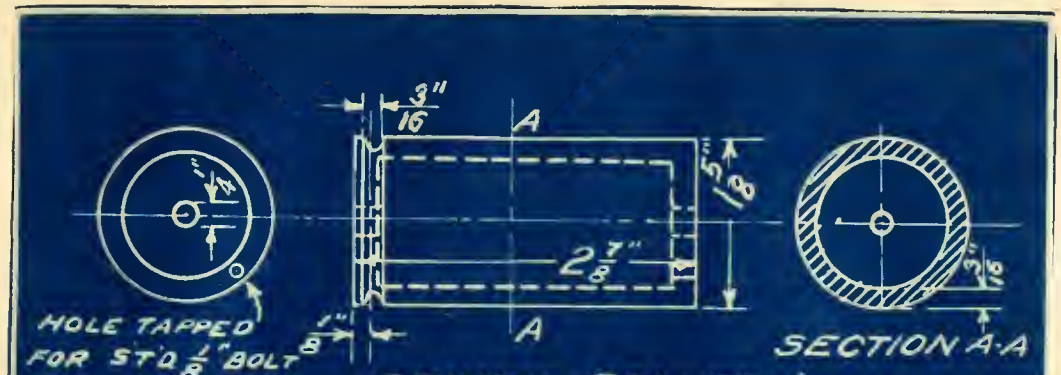
BLUEPRINTS.



Traction spots of U.S. Plain 30"×3½" Tire.


STANDARD FOR
RECORDING DEVICE
A THESIS
ON
SHOCK ABSORPTION
OF AUTOMOBILE TIRES.
SCALE:- 5"=1FT.
MAY 9, 1920.
DRAWN BY Chas. A. Young
4 HOLES
TAPPED FOR
3/8" STD BOLT.
1/8" HOLE FOR
PIN
DRILL 1/2"
DRILL 1/4"
5"
3"
IREG'D.

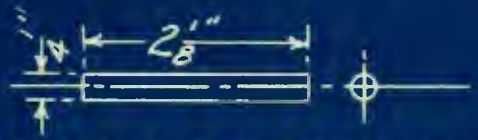

1/8" HOLE FOR PIN
1 9/16"
1/2"
3"
ROLLER SHAFT-2.
1"
ROLLER SHAFT PIN-2
1/64" RECESS
2 3/8"
2 7/8"
2 1/2"
1/8"
5/16"
PAPER GUIDE-2
DRILL 9/64"
20G.
2 3/8"
PAPER HOLDER-2.
A
THESIS
ON
SHOCK ABSORPTION
OF AUTOMOBILE TIRES.
SCALE:-6"=1FT.
MAY 9 1920
DRAWN BY Philip D Sang



DRIVING ROLLER-1

DRIVEN ROLLER-1

LIKE ABOVE WITHOUT GROOVE BUT WITH HOLE TAPPED IN TOP FOR STD. 1/8" BOLT.



IDLER PULLEY SHAFT-1

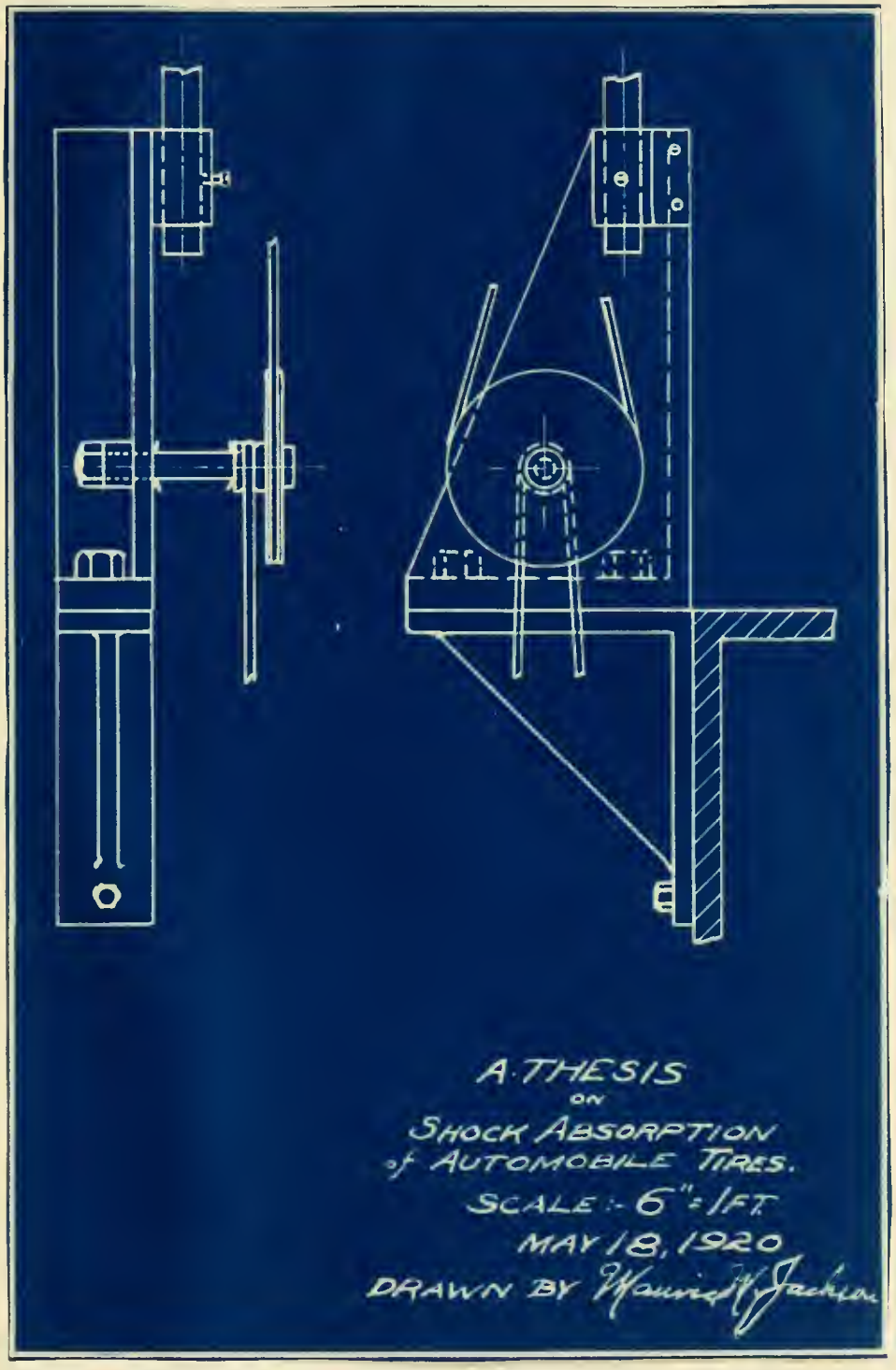
IDLER PULLEY-2

A THESIS
ON
SHOCK ABSORPTION
OF AUTOMOBILE TIRES.

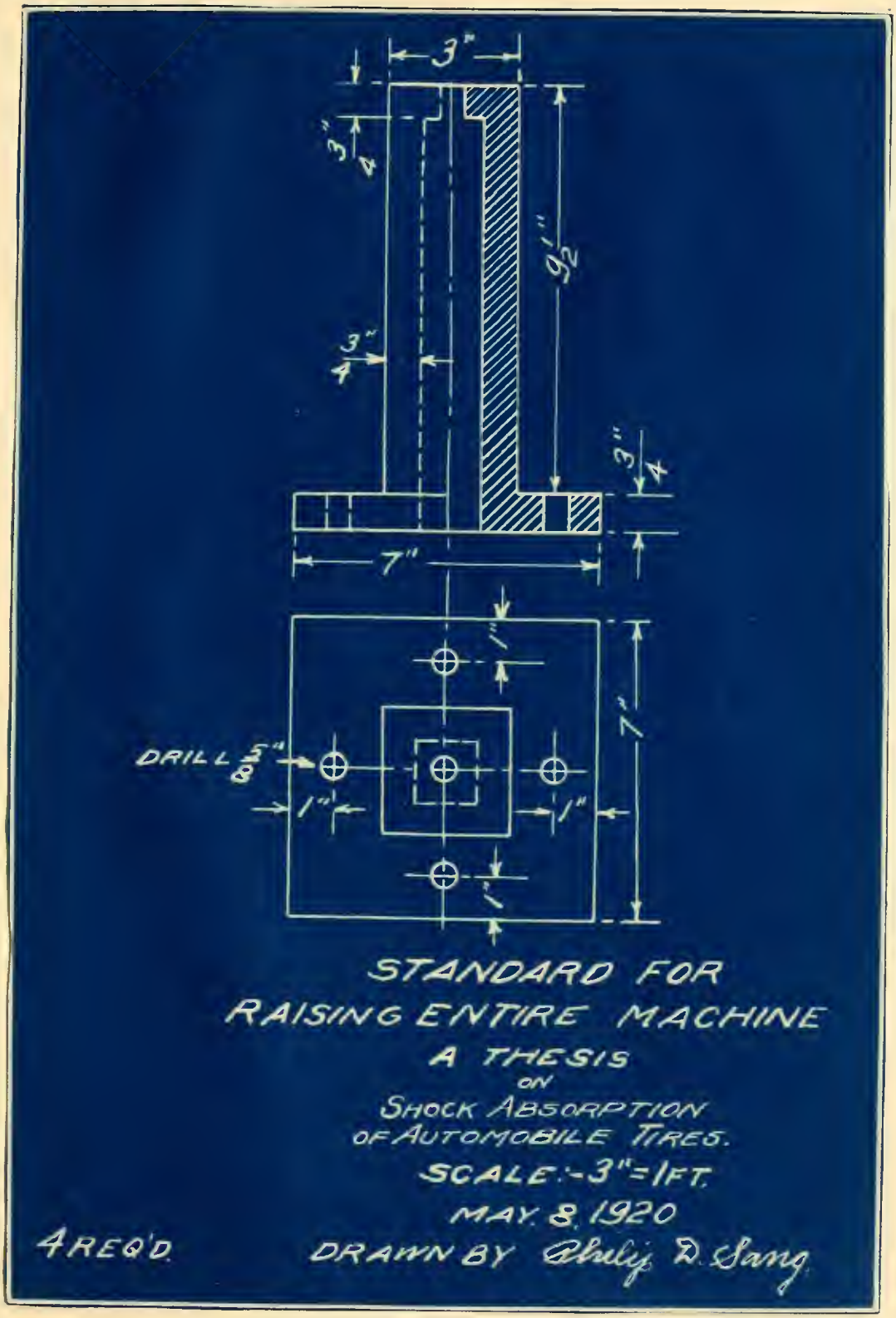
SCALE :- 6" = 1 FT.

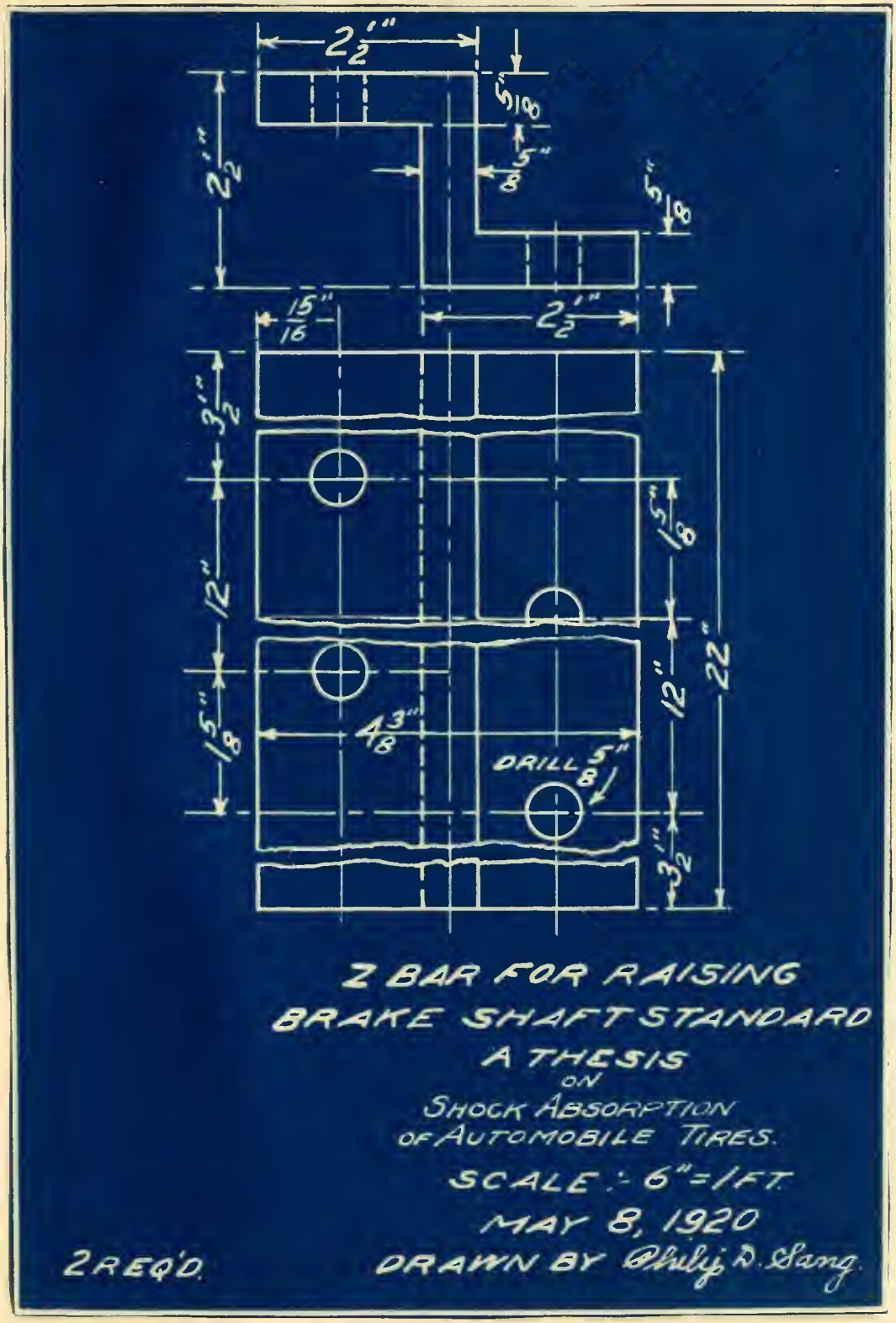
MAY. 9 1920

DRAWN BY Philip D. Sang



A THESIS
ON
SHOCK ABSORPTION
of AUTOMOBILE TIRES.
SCALE :- 6" = 1 FT.
MAY 18, 1920
DRAWN BY Maurice H. Jackson


3"
3"
4
9 1/2"
3"
4
3"
4
7"
1"
7"
DRILL 5/8"
1"
1"
1"
STANDARD FOR
RAISING ENTIRE MACHINE
A THESIS
ON
SHOCK ABSORPTION
OF AUTOMOBILE TIRES.
SCALE:- 3" = 1 FT.
MAY. 8. 1920
4 REQ'D.
DRAWN BY Philip D. Sang.



Z BAR FOR RAISING
BRAKE SHAFT STANDARD
A THESIS
ON
SHOCK ABSORPTION
OF AUTOMOBILE TIRES.
SCALE :- 6" = 1 FT.
MAY 8, 1920
2 REQ'D.
DRAWN BY Philip D. Stang.

FINIS